ACM Technical Report

ACM-TR-121

(NASA-CR-160703) MISSION ANALYSIS DATA FOR INCLINED GEOSYNCHRONOUS ORBITS, PART 2. APPENDIX A: BIBLIOGRAPHY (Analytical and Computational Mathematics, Inc.) 50 p HC A03/MF A01 CSCL 22A G3/12

N80-26340

Unclas 23608

MISSION ANALYSIS DATA FOR INCLINED GEOSYNCHRONOUS ORBITS

PART 2

ANALYTICAL AND COMPUTATIONAL MATHEMATICS, INC.

APPENDIX A:

BIBLIOGRAPHY

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Inclined Geosynchronous "Halo" Orbit Study

(1) "Payload Cluster Concepts Study", Final Summary Report, Contract No. NAS8-32143 for the Marshall Space Center, IBM Corporation, April 7, 1977.

Summary: This is a systems study. It has some results on orbit correction delta V requirements for geosynchronous orbits with inclinations of 2 deg. The following results are on page 2-16
Delta V N/S = 850 ft/sec for five years
Delta V N/S = 255 ft/sec for 1.5 years = 170 ft/sec/yr
Delta V E/W = 210 ft/sec for five years
Delta V E/W = 63 ft/sec for 1.5 years = 42 ft/sec/yr

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(2) R.H. Frick and T.B. Garber, "Perturbations of a Synchronous Satellite Due To Triaxiality of the Earth", Journal of the Aerospace Sciences, Sept., 1962.

Summary: Gives a discussion of J2 and J22 case. Develops a two-burn maneuver for correcting longitude drift. This is used to estimate delta V requirements for N/S drift. Only the circular, equatorial case is treated.

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(3) R.H. Frick, "Orbital Regression of Synchronous Satellites Due to the Combined Gravitational Effects of the Sun, the Moon and Oblate Earth", Rand Corp. report to NASA, August, 1967.

Summary: Treats only the case of motion of the orbit plane. Equations are needlessly complicated and not useful to us. However, he discusses out-of-plane orbit corrections that we could use as a check on our results.

(4) L. Blitzer, E.M. Boushton, G. Kang, R.M. Page, "Effect of Ellipticity of the Equator on 24-Hour Nearly Circular Satellite Orbits", Journal of Geophysical Research, Vol. 67, No. 1, January, 1962.

Summary: This is one of the important early papers on E/W drift of geosynchronous satellites. It contains useful plots of drift rates and drift regimes.

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(5) "Geosynchronous Platform Definition Study, Volume III, Geosynchronous Mission Characteristics", Rockwell International Space Division, Report to Johnson Space Center, Contract NAS9-12909, June, 1973.

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(6) D.L. Akin, "Some Applications of Nonstationary Geosynchronous Orbits", presented at the AIAA/AAS Astrodynamics Conference, Palo Alto, Calif., August 7-9, 1978. AIAA Paper No. 78-1407.

Summary: Discusses applications of inclined, eccentric geosynchronous orbits. Does not consider the effects of orbit perturbations.

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(7) C.A Wagner, "The Drift of an Inclined-Orbit 24-Hour Satellite in an Earth Gravity Field Throush Fourth Order", NASA Technical Note TN D-3316, Goddard Space Flight Center, August, 1966.

Summary: Useful equations for E/W drift for inclined orbits. No info on orbit corrections. This paper is intended to support the determination of geopotential coefficients.

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(8) C.A. Wagner, "The Drift of a 24-Hour Equatorial Satellite Due to an Earth Gravity Field Through Fourth Order", NASA Technical Note D-2103, February, 1964.

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(9) C.A. Wagner, "Determination of the Ellipticity of the Earth's Equator from Observations on the Drift of the Syncom II Satellite", NASA Technical Note D-2759, May, 1965.

Summary: Gives the basic analysis of drift of inclined geosynchronous orbits. Describes the physical effects on the inclined orbit. Has much useful reference equations and data. We need to also get copies of the Appendices.

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(10) C.A. Wagner, "The Equatorial Ellipticity of the Earth from Two Months of Syncom II Drift Over the Central Pacific", NASA Technical Note D-3315, 1966.

Summary: Follow-up paper to Reference (9)

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(11) A. Kamel, D. Ekman and R. Tibbitts, "East-West Stationkeeping Requirements of Nearly Synchronous Satellites Due to Earth's Triaxiality and Luni-Solar Effects", Celestial Mechanics, Vol. 8, pages 129-148, 1973.

Summary: This paper presents the station requirements for E/W drift for equatorial orbits. We do not need this level of detail, but this paper will be useful as a check on our own results. Max delta V requirement is 6 ft/sec/yr at 120 deg longitude. Deadband is +- 3 deg.

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(12) M.C. Eckstein, "Zur Positionshaltung Geostationaerer Satelliten", IB 552-76/17 Institut fuer Dynamik Flugsysteme, Oberpfaffenhofen, November 11, 1976.

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(13) B.H. Billik, "Cross-Track Sustaining Requirements for a 24-Hr Satellite", Journal of Spacecraft, Vol. 4, No. 3, March, 1967.

Summary: Gives a primitive solution for inclination as a function of time. Useful equations and a technique is given for computing the cross track sustaining velocity requirements. We may be able to use these equations. His analysis is only valid for nearly equatorial orbits. He assumes that the desired incl is zero, and the max allowable inclination is 4.6 deg.

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(14) A. Kamel and R. Tibbitts, "Some Useful Results on Initial Node Locations for Near-Equatorial Circular Satellite Orbits", CELESTIAL MECHANICS, Vol. 8, pages 45-73, 1973.

Summary: Gives a more precise solution for inclination time history than Billik, or any other author that I know of. They include the effect of the precession of the moon's orbit. However, analysis is only good for nearly equatorial orbits. Delta V requirements are not discussed.

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(15) O. Graf, "Lunar and Solar Perturbations on the Orbit of a Geosynchronous Satellite", Presented at the AAS/AIAA Astrodynamics Specialist Conference, Nassau, Bahamas, July 28-30, 1975, AAS Paper No. 75-023.

Summary: Gives a useful solution to motion of orbital plane for orbits near the equatorial plane.

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(16) "Physical Nature and Technical Attributes of the Geostationary Orbit", Study prepared by the UN Secretariat, 11 December 1978, A/AC.105/203/Add.1

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(17) R.R. Allan, "Satellite Resonance With Longitude-Dependent Gravity-II, Effects Involving the Eccentricity", PLANETARY AND SPACE SCIENCES, Vol. 15, pp.1829-1845, 1967.

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(18) O.F. Graf, "Orbital Motion of the Solar Power Satellite", ACM Technical Report TR-105, May, 1977.

Availibility: Orisinal copy in ACM, Inc. office.

Summary: This report develops the equations for the long term effect of solar radiation pressure on a geosynchronous orbit. Useful equations are given for any inclination, but an analytical solution is given only for the case of small eccentricity and inclination. Only solar radiation pressure is considered, gravitational forces are not included in the analysis.

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(19) O.L. Dial and J.L. Cooley, "Mission Design Implications of an Inclined Elliptical Geosynchronous Orbit (International Ultraviolet Explorer)", AIAA paper No. 76-812, presented at the AIAA/AAS Astrodynamics Conference, San Diego, Calif. 18-20 August 1976.

Summary: This is an example of the application of an inclined and eccentric geosynchronous orbit (I=28.6 deg , ecc = .25).

(20) J.C. Van der Ha, "Very Long Term Orbit Evolution of a Geostationary Satellite", European Space Operations Centre, Mission Analysis Office, Working Paper No. 122, March 1980.

Summary: A major part of the report describes the analytical method for first order analytical averaging of the perturbation equations. The goal is to develop a computer program that propagates the elements over long periods of time (20 years). The averaging method requires much less computer time that conventional numerical methods. Computer generated plots of orbital elements are given. All important perturbing forces are considered.

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APPENDIX B:

LISTINGS OF COMPUTER PROGRAMS

ROUTINES IN PROGRAM EDRIFT

```
1           CD0
2  0000001          PROGRAM EDRIFT
3           CD0 (TAB STOPS ARE 7,10,12,22,25,28,39)
4           CD0
5           CD0      PROGRAMMED BY:              OTIS F. GRAF , ACM,INC.
6           CD0                                  FEBRUARY 1979
7           CD0
8           CD0
9           CD0      CODE MODIFIED BY:           OTIS F. GRAF , ACM,INC.
10          CD0                                  25 APRIL 1980
11          CD0
12          CD0
13          CD0      DOCUMENTATION UPDATED BY:   OTIS F. GRAF , ACM,INC.
14          CD0                                  21 APRIL 1980
15          CD0
16          C=====================================================================
17          CD1
18          CD1    PURPOSE
19          CD1
20          CD1    This program computes and plots the long term eccentricity drift
21          CD1    of a geosynchronous satellite in a nearly circular orbit.
22          CD1
23          C=====================================================================
24          CD2
25          CD2    DEFINITION OF INPUT
26          CD2
27          CD2       CRT TERMINAL INPUTS
28          CD2
29          CD2         SYMBOL    D  T  DEFINITION
30          CD2         ------   --- -  ----------
31          CD2
32          CD2         INC       1  D  Orbital inclination (deg)
33          CD2
34          C=====================================================================
35          CD3
36          CD3    DEFINITION OF OUTPUT
37          CD3
38          CD3       TERMINAL OUTPUT
39          CD3
40          CD3         SYMBOL    D  T  DEFINITION
41          CD3         ------   --- -  ----------
42          CD3         TIME      1  D  Time of propagation (days)
43          CD3
44          CD3         P         1  D  Non-singular element (non-dimensional)
45          CD3
46          CD3         Q         1  D  Non-singular element (non-dimensional)
47          CD3
48          CD3         ECC       1  D  Orbital eccentricity
49          CD3
50          CD3
51          CD3       DATA FILES
52          CD3
53          CD3         SYMBOL    D  T  DEFINITION
54          CD3         ------   --- -  ----------
55          CD3         XOUT      1  R  (1): X-component of data to be plotted
56          CD3                         (2): Y-component of data to be plotted
57          CD3
58          C=====================================================================
```

```
 59              CD4
 6Ø              CD4   COMMON VARIABLES DEFINITION
 61              CD4
 62              CD4         INTERNAL          COMMON
 63              CD4          SYMBOL    D  T   SYMBOL      DEFINITION
 64              CD4         --------- --- -  ------      ----------
 65              CD4         PI          1  D  DPICON(1)  Mathematical constant Pi
 66              CD4         TWOPI       1  D  DPICON(2)  2*Pi
 67              CD4         HALFPI      1  D  DPICON(3)  Pi/2
 68              CD4         DTOR        1  D  DPICON(4)  Conversion factor degrees to radians
 69              CD4         RTOD        1  D  DPICON(5)  Radians to degrees
 7Ø              CD4         MNTODY      1  D  DPICON(5)  Minutes to days
 71              CD4         DYTOMN      1  D  DPICON(6)  Days to minutes
 72              CD4         MUE         1  D  DGCON( 1)  Earth gravitational parameter,
 73              CD4                                      units are (ER cu)/(min sq)
 74              CD4         WE          1  D  DGCON( 2)  Rotation rate of the earth (rad/min)
 75              CD4         J2          1  D  DGCON( 3)  Obiateness geopotential parameter
 76              CD4         J22         1  D  DGCON( 4)  Equatorial ellipticity geopotential
 77              CD4                                      parameter (non-dimensional)
 78              CD4         LAM22       1  D  DGCON( 5)  Equatorial ellipticity geopotential
 79              CD4                                      parameter (radians)
 8Ø              CD4         RE          1  D  DGCON( 6)  Earth equatorial radius(earth radii)
 81              CD4         APERW       1  D  DGCON( 7)  Satellite cross-sectional area
 82              CD4                                      divided by weight (meters sq/kg)
 83              CD4         S           1  D  DGCON( 8)  Sine of the ecliptic angle
 84              CD4         C           1  D  DGCON( 9)  Cosine of the ecliptic angle
 85              CD4         FI          1  D  CONST( 1)  Inclination function for J22 term
 86              CD4         F22         1  D  CONST( 2)  Abbreviation for J22 term
 87              CD4         ASYNC       1  D  CONST( 3)  Semi-major axis for geosynchronous
 88              CD4                                      orbit (earth radii)
 89              CD4         EPSLN       1  D  CONST( 4)  Small parameter used in the solar
 9Ø              CD4                                      radiation pressure equations
 91              CD4         RATE        1  D  CONST( 5)  Angular rate used in solar radition
 92              CD4                                      pressure equations. 1.DØ/365.25DØ
 93              CD4         BP          1  D  CONST( 6)  Non-singular element for inclination
 94              CD4         BQ          1  D  CONST( 7)  Non-singular element for inclination
 95              CD4         INC         1  D  CONST( 8)  Orbital inclination (rad)
 96              CD4         ASCND       1  D  CONST( 9)  Ascending node (rad)
 97              CD4         SUNPOS      1  D  CONST(1Ø)  Angular position of the sun in the
 98              CD4                                      ecliptic plane, measured from the
 99              CD4                                      vernal equinox (rad)
1ØØ              CD4
1Ø1             C=====================================================================
1Ø2             CD6
1Ø3             CD6   EXTERNAL REFERENCES
1Ø4             CD6
1Ø5             CD6      EXTERNAL ROUTINES
1Ø6             CD6        EINPUT, RKF45
1Ø7             CD6
1Ø8             C=====================================================================
1Ø9             CD7
11Ø             CD7   FUNCTIONAL DESCRIPTION
111             CD7
112             CD7   This is the main routine for computine the motion of eccentricity
113             CD7   and line of apsides for a geosynchronous orbit. This routine also
114             CD7   writes an output file that can be input to the PLOTIT program.
115             CD7   The output file contains data on eccentricity vs time, or P
116             CD7   vs Q.
```

```
117              CD7
118              CD7   EDRIFT first calls some system routines to open the output file.
119              CD7   Then EINPUT is called to get initial inputs and to initialize
12Ø              CD7   constants. The routine contains a numerical integration loop that
121              CD7   calls the Runge-Kutta routine (RKF45) to solve the differential
122              CD7   equations for P and Q.  After each integration step, EDRIFT will
123              CD7   print to the CRT screen: time, eccentricity, P and Q.
124              CD7
125              CD7   After the final time has been reached, the routine prompts for
126              CD7   another value of inclination. It will then redo the solution for
127              CD7   eccentricity, using the new value for inclination. In order to
128              CD7   terminate execution, enter a negative value for inclination.
129              CD7
13Ø              CD7   The complete EDRIFT program consists of the following routines:
131              CD7      EDRIFT: Main program and integration driver
132              CD7      EINPUT: Routine for input and initialization of COMMON variables
133              CD7      EDERIV: Computes the right sides of the differential equations
134              CD7      RKF45 : Runge-Kutta numerical integration routine (part of the
135              CD7              FDS-2 utility library)
136              CD7
137              C=====================================================================
138              CD8
139              CD8   ASSUMPTIONS AND LIMITATIONS
14Ø              CD8
141              CD8   1) Only solar radiation pressure is included in the analytical
142              CD8      expression of the differential equations for P and Q.
143              CD8
144              C=====================================================================
145              CD1Ø
146              CD1Ø  REFERENCES
147              CD1Ø
148              CD1Ø
149              C*********************************************************************
15Ø              C     SPECIFICATION STATEMENTS
151              C     ------------------------
152              C
153              C     IMPLICIT
154              C     --------
155   ØØØØØ6I          IMPLICIT DOUBLE PRECISION (A-H,O-Z)
156              C
157              C     DOUBLE PRECISION
158              C     ----------------
159   ØØØØØ6I          DOUBLE PRECISION LNGØ   ,   LNG    ,   LNGDØ  ,   LNGD   ,
16Ø                *                  MUE    ,   J2     ,   J22    ,   MNTODY,
161                *                  INC
162              C
163              C     REAL
164              C     ----
165   ØØØØØ6I          REAL XOUT
166              C
167              C     DIMENSION
168              C     ---------
169   ØØØØØ6I          DIMENSION DEPVAR(2)  ,  WRKARY(14)  ,  SCALE(2) , XOUT(2)
17Ø              C
171              C     COMMON
172              C     ------
173   ØØØØØ6I          COMMON /CONST  /CONST(1Ø)
174   ØØØØØ6I          COMMON /DGCON  /DGCON(1Ø)
```

```
175  000006I          COMMON /DPICON /DPICON(10)
176              C
177              C     EQUIVALENCE
178              C     -----------
179  000006I          EQUIVALENCE (PI      ,DPICON( 1)),
180                 *            (TWOPI   ,DPICON( 2)),
181                 *            (HALFPI  ,DPICON( 3)),
182                 *            (DTOR    ,DPICON( 4)),
183                 *            (RTOD    ,DPICON( 5)),
184                 *            (MNTODY  ,DPICON( 6)),
185                 *            (DYTOMN  ,DPICON( 7))
186  000006I          EQUIVALENCE (MUE     ,DGCON ( 1)),
187                 *            (WE      ,DGCON ( 2)),
188                 *            (J2      ,DGCON ( 3)),
189                 *            (J22     ,DGCON ( 4)),
190                 *            (LAM22   ,DGCON ( 5)),
191                 *            (RE      ,DGCON ( 6))
192  000006I          EQUIVALENCE (FI      ,CONST ( 1)),
193                 *            (F22     ,CONST ( 2)),
194                 *            (ASYNC   ,CONST ( 3)),
195                 *            (BP      ,CONST ( 6)),
196                 *            (BQ      ,CONST ( 7)),
197                 *            (INC     ,CONST ( 8)),
198                 *            (ASCND   ,CONST ( 9))
199              C
200              C     EXTERNAL
201              C     --------
202  000006I          EXTERNAL EDERIV
203              C
204              C     DATA
205              C     ----
206  000006I          DATA SCALE /2*1.D0/,
207                 *     IFLAG /1/,
208                 *     NDEQ  /2/,
209                 *     TOL   /1.D0/,
210                 *     DUM   /0.D0/
211  0000BCI          DATA PLOTFL /'PLOT.DAT'/,
212                 *     LRLTH /8/
213              C
214              C
215              C*********************************************************************
216              C
217  0000C8I          CALL CFILW(PLOTFL,2,LRLTH,1,1,0,0,ISTAT)
218  000124I          IF(ISTAT.EQ.4) THEN
219  000134I             CALL DFILW(PLOTFL,0,0,ISTAT)
220  000168I             CALL CFILW(PLOTFL,2,LRLTH,1,1,0,0,ISTAT)
221  0001C4I          ENDIF
222  0001CAI          CALL OPENW(6,PLOTFL,4,0,0,ISTAT)
223              C
224  000214I          CALL EINPUT(PS,QS,DTAUS,TAUF,ISTOP,IPLOT)
225              C
226  000240I        500 CONTINUE
227  000240I          DEPVAR(1) = PS
228  00024AI          DEPVAR(2) = QS
229  000254I          TAU = 0.D0
230  000260I          DTAU = DTAUS
231  00026CI          NUMSTP = 0
232  000274I          ISTART = 1
```

```
233              C
234  ØØØ27CI            ECC = DSQRT(PS**2 + QS**2)
235  ØØØ2C6I            IF(IPLOT.EQ.2) THEN
236  ØØØ2D6I               XOUT(1) = Ø.Ø
237  ØØØ2EØI               XOUT(2) = SNGL(ECC)
238  ØØØ2FCI               WRITE(6) XOUT
239  ØØØ354I            ENDIF
24Ø              C
241  ØØØ35AI            IF(IPLOT.EQ.1) THEN
242  ØØØ36AI               XOUT(1) = SNGL(P)
243  ØØØ384I               XOUT(2) = SNGL(Q)
244  ØØØ3AØI               WRITE(6) XOUT
245  ØØØ3F8I            ENDIF
246              C
247  ØØØ3FEI            WINC = INC*RTOD
248  ØØØ41ØI            WRITE (5,2Ø1) WINC
249  ØØØ464I      2Ø1 FORMAT(' INCLINATION =',F8.2)
25Ø  ØØØ488I            TIME = TAU/TWOPI
251  ØØØ49AI            WRITE (5,2ØØ) NUMSTP,TIME,PS,QS,ECC
252              C
253  ØØØ4FCI     1ØØØ CONTINUE
254  ØØØ4FCI            NUMSTP = NUMSTP + 1
255  ØØØ5ØAI            SVP = DEPVAR(1)
256  ØØØ514I            SVQ = DEPVAR(2)
257  ØØØ51EI            SVTAU = TAU
258              C
259  ØØØ52AI            CALL RKF45(TAU,DTAU,DUM,DEPVAR,SCALE,TOL,NDEQ,IFLAG,EDERIV,
26Ø                   * NREJCT,WRKARY,IERR)
261              C
262  ØØØ56CI            P = DEPVAR(1)
263  ØØØ576I            Q = DEPVAR(2)
264  ØØØ58ØI            ECC = DSQRT(P**2 + Q**2)
265  ØØØ5CAI            TIME = TAU/TWOPI
266              C
267  ØØØ5DCI            WRITE (5,2ØØ) NUMSTP,TIME,P,Q,ECC
268  ØØØ64ØI      2ØØ FORMAT(1X,I3,2X,'TIME = ',F6.Ø,2X,'P =',D12.3,2X,'Q =',D12.3,
269                   * 2X,'ECC =',D12.3)
27Ø              C
271  ØØØ694I            IF(IPLOT.EQ.1) THEN
272  ØØØ6A4I               XOUT(1) = SNGL(P)
273  ØØØ6CØI               XOUT(2) = SNGL(Q)
274  ØØØ6DCI               WRITE(6) XOUT
275  ØØØ734I            ENDIF
276              C
277              C
278  ØØØ73AI            IF(IPLOT.EQ.2) THEN
279  ØØØ74AI               XOUT(1) = SNGL(TIME)
28Ø  ØØØ764I               XOUT(2) = SNGL(ECC)
281  ØØØ78ØI               WRITE(6) XOUT
282  ØØØ7D8I            ENDIF
283  ØØØ7DEI            IF(TAU.LT.TAUF) GO TO 1ØØØ
284  ØØØ7F4I            WRITE (5,1Ø1)
285  ØØØ83ØI      1Ø1 FORMAT(' INPUT INCLINATION (DEG) - G18.7')
286  ØØØ86ØI            READ (5,169) INC
287  ØØØ8B4I            IF(INC.LT.Ø.DØ) GO TO 9999
288  ØØØ8CCI            INC = INC*DTOR
289  ØØØ8DEI            BP = DSQRT(1.DØ - DCOS(INC)) * DCOS(ASCND)
29Ø  ØØØ94ØI            BQ = DSQRT(1.DØ - DSIN(INC)) * DSIN(ASCND)
```

```
291  0009A4I          GO TO 500
292  .           C
293  0009A8I      169 FORMAT(G18.7)
294  0009BCI     9999 CONTINUE
295  0009BCI          CALL EXIT
296              C
297  0009C8I          END
```

NO ERRORS:F7D R03-00.0 MAINPROG EDRIFT 05/01/80 09:38:01 TABLE SPACE: 4 KB
STATEMENT BUFFER: 20 LINES/1321 BYTES STACK SPACE: 105 WORDS
SINGLE PRECISION FLOATING PT SUPPORT REQUIRED FOR EXECUTION
DOUBLE PRECISION FLOATING PT SUPPORT REQUIRED FOR EXECUTION

```
 1              CDØ
 2  ØØØØØØI          SUBROUTINE EINPUT(P,Q,DTAU,TAUF,ISTOP,IPLOT)
 3              CDØ (TAB STOPS ARE 7,1Ø,12,22,25,28,39)
 4              CDØ
 5              CDØ      PROGRAMMED BY:              OTIS F. GRAF , ACM,INC.
 6              CDØ                                  FEBRUARY 198Ø
 7              CDØ
 8              CDØ
 9              CDØ      CODE MODIFIED BY:           OTIS F. GRAF , ACM,INC.
10              CDØ                                  21 APRIL 198Ø
11              CDØ
12              CDØ
13              CDØ      DOCUMENTATION UPDATED BY:   OTIS F. GRAF , ACM,INC.
14              CDØ                                  21 APRIL 198Ø
15              CDØ
16              C=====================================================================
17              CD1
18              CD1    PURPOSE
19              CD1
20              CD1    This is the input and data initialization routine for the
21              CD1    EDRIFT program.
22              CD1
23              C=====================================================================
24              CD2
25              CD2    DEFINITION OF INPUT
26              CD2
27              CD2       CRT TERMINAL INPUTS
28              CD2
29              CD2         SYMBOL     D  T  DEFINITION
30              CD2         ------    --- -  ----------
31              CD2         ASCND      1  D  Initial longitude of ascending node, measured
32              CD2                           along the equator from the X-axis of the
33              CD2                           inertial coordinate system. (deg)
34              CD2
35              CD2         INC        1  D  Orbital inclination. (deg)
36              CD2
37              CD2         DTAU       1  D  Stepsize for the RKF45 numerical integra-
38              CD2                           tion. (days)
39              CD2
40              CD2         TAUF       1  D  Final time for the orbital elements
41              CD2                           propagation. (days)
42              CD2
43              CD2         ISTOP      1  I  (not used)
44              CD2
45              CD2         IPLOT      1  I  Plot flag
46              CD2
47              CD2         APERW      1  D  Crossectional surface area of satellite
48              CD2                           divided by its weight (meters sq / kg)
49              CD2
50              C=====================================================================
51              CD3
52              CD3    DEFINITION OF OUTPUT
53              CD3
54              CD3       CALLING ARGUMENTS
55              CD3
56              CD3         SYMBOL     D  T  DEFINITION
57              CD3         ------    --- -  ----------
58              CD3         P          1  D
```

```
 59             CD3
 60             CD3         Q          1  D
 61             CD3
 62             CD3         DTAU       1  D
 63             CD3
 64             CD3         TAUF       1  D
 65             CD3
 66             CD3         ISTOP      1  I  (not used)
 67             CD3
 68             CD3         IPLOT      1  I  Plot flag
 69             CD3
 70             CD3
 71             CD3       COMMON ARRAYS
 72             CD3         DPICON, DGCON, CONST
 73             CD3
 74             C=====================================================================
 75             CD4
 76             CD4    COMMON VARIABLES DEFINITION
 77             CD4
 78             CD4         INTERNAL          COMMON
 79             CD4          SYMBOL    D  T   SYMBOL      DEFINITION
 80             CD4         --------  --- -  ------      ----------
 81             CD4
 82             C=====================================================================
 83             CD6
 84             CD6    EXTERNAL REFERENCES
 85             CD6
 86             CD6       EXTERNAL ROUTINES
 87             CD6         (NONE)
 88             CD6
 89             C=====================================================================
 90             CD7
 91             CD7    FUNCTIONAL DESCRIPTION
 92             CD7
 93             CD7    This is the input and initialization routine for the EDRIFT
 94             CD7    program.  It promts the user via the CRT for user inputs.
 95             CD7    These inputs are passed to the EDRIFT  and EDERIV routines.
 96             CD7    Common blocks are also defined by the EINPUT routine.
 97             CD7
 98             C=====================================================================
 99             CD8
100             CD8    ASSUMPTIONS AND LIMITATIONS
101             CD8
102             CD8    1) The eccentricity in initialized at zero for all cases.  Thus
103             CD8       the argument of perigee is initially undefined.
104             CD8
105             CD8    2) The initial position of the sun in inertial corresponds to
106             CD8       the epoch of 1 January 1980.
107             CD8
108             C=====================================================================
109             CD10
110             CD10   REFERENCES
111             CD10
112             CD10
113             C*********************************************************************
114             C      SPECIFICATION STATEMENTS
115             C      ------------------------
116             C
```

```
117             C     IMPLICIT
118             C     --------
119  ØØØØØ4I          IMPLICIT DOUBLE PRECISION (A-H,O-Z)
12Ø             C
121             C     DOUBLE PRECISION
122             C     ----------------
123  ØØØØØ4I          DOUBLE PRECISION  LNGØ   ,   LNGDØ   ,   INC   ,  MUE   ,
124                 *                  LAM22  ,   J2      ,   J22   ,  MNTODY
125             C
126             C     COMMON
127             C     ------
128  ØØØØØ4I          COMMON /CONST  /CONST(1Ø)
129  ØØØØØ4I          COMMON /DGCON  /DGCON(1Ø)
13Ø  ØØØØØ4I          COMMON /DPICON /DPICON(1Ø)
131             C
132             C     EQUIVALENCE
133             C     -----------
134  ØØØØØ4I          EQUIVALENCE (PI     ,DPICON( 1)),
135                 *             (TWOPI  ,DPICON( 2)),
136                 *             (HALFPI ,DPICON( 3)),
137                 *             (DTOR   ,DPICON( 4)),
138                 *             (RTOD   ,DPICON( 5)),
139                 *             (MNTODY ,DPICON( 6)),
14Ø                 *             (DYTOMN ,DPICON( 7))
141  ØØØØØ4I          EQUIVALENCE (MUE    ,DGCON ( 1)),
142                 *             (WE     ,DGCON ( 2)),
143                 *             (J2     ,DGCON ( 3)),
144                 *             (J22    ,DGCON ( 4)),
145                 *             (LAM22  ,DGCON ( 5)),
146                 *             (RE     ,DGCON ( 6)),
147                 *             (APERW  ,DGCON ( 7)),
148                 *             (S      ,DGCON ( 8)),
149                 *             (C      ,DGCON ( 9))
15Ø  ØØØØØ4I          EQUIVALENCE (FI     ,CONST ( 1)),
151                 *             (F22    ,CONST ( 2)),
152                 *             (ASYNC  ,CONST ( 3)),
153                 *             (EPSLN  ,CONST ( 4)),
154                 *             (RATE   ,CONST ( 5)),
155                 *             (BP     ,CONST ( 6)),
156                 *             (BQ     ,CONST ( 7)),
157                 *             (INC    ,CONST ( 8)),
158                 *             (ASCND  ,CONST ( 9)),
159                 *             (SUNPOS ,CONST (1Ø))
16Ø             C
161             C*********************************************************************
162             C
163  ØØØØØ4I          PI = 3.141592653589793DØ
164  ØØØØ1ØI          TWOPI = 2.DØ*PI
165  ØØØØ22I          RTOD = 18Ø.DØ/PI
166  ØØØØ34I          DTOR = PI/18Ø.DØ
167  ØØØØ46I          MNTODY = 1.ØDØ/144Ø.DØ
168  ØØØØ58I          DYTOMN = 144Ø.DØ
169             C
17Ø  ØØØØ64I          J2    = 1.Ø8248D-3
171  ØØØØ7ØI          J22   = 1.7711563D-6
172  ØØØØ7CI          LAM22 = 75.Ø73DØ * DTOR
173  ØØØØ8EI          WE    = 4.375269513D-3
174  ØØØØ9AI          MUE   = 5.53Ø263286D-3
```

```
175  ØØØØA6I          RE     = 1.DØ
176  ØØØØB2I          S      = DSIN(23.5*DTOR)
177  ØØØØEEI          C      = DCOS(23.5*DTOR)
178  ØØØ12AI          RATE   = 1.DØ/365.25
179  ØØØ148I          SUNPOS = -8Ø.6*DTOR
18Ø              C
181  ØØØ166I          ASYNC = 6.61Ø668747DØ
182  ØØØ172I          F22   =  Ø.DØ
183  ØØØ17EI          FI    =  Ø.DØ
184              C
185              C
186  ØØØ18AI          WRITE (5,1ØØ)
187  ØØØ1C4I     1ØØ FORMAT(' INPUT ASCENDING NODE (DEG) - G18.7')
188  ØØØ1F8I          READ (5,169) ASCND
189  ØØØ24CI          ASCND = ASCND * DTOR
19Ø              C
191  ØØØ25EI          WRITE (5,1Ø1)
192  ØØØ298I     1Ø1 FORMAT(' INPUT INCLINATION (DEG) - G18.7')
193  ØØØ2C8I          READ (5,169) INC
194  ØØØ31CI          INC = INC * DTOR
195              C
196  ØØØ32EI          WRITE (5,1Ø2)
197  ØØØ368I     1Ø2 FORMAT(' INPUT DTAU & TAUF (DAYS) - G18.7')
198  ØØØ398I          READ (5,169) DTAU
199  ØØØ3ECI          READ (5,169) TAUF
2ØØ  ØØØ44ØI          DTAU = DTAU*TWOPI
2Ø1  ØØØ452I          TAUF = TAUF*TWOPI
2Ø2              C
2Ø3  ØØØ464I          WRITE (5,1Ø3)
2Ø4  ØØØ4AØI     1Ø3 FORMAT(' INPUT STOP FLAG - I1'/' 1 : STOP ON TIME'/
2Ø5                 * ' 2 : STOP ON ORBIT')
2Ø6  ØØØ4ECI          READ (5,269) ISTOP
2Ø7              C
2Ø8  ØØØ54ØI          WRITE (5,1Ø4)
2Ø9  ØØØ57CI     1Ø4 FORMAT(' INPUT PLOT FLAG - I1'/' 1 : P VS Q'/
21Ø                 * ' 2 : ECC VS TIME')
211  ØØØ5CØI          READ (5,269) IPLOT
212              C
213              C
214  ØØØ614I          WRITE (5,1Ø5)
215  ØØØ65ØI     1Ø5 FORMAT(' INPUT AREA PER WEIGHT - G18.7')
216  ØØØ67CI          READ (5,169) APERW
217              C
218  ØØØ6DØI          BP = DSQRT(1.DØ - DCOS(INC)) * DCOS(ASCND)
219  ØØØ734I          BQ = DSQRT(1.DØ - DCOS(INC)) * DSIN(ASCND)
22Ø  ØØØ798I          AOVG = (5.Ø6D-7)* APERW
221  ØØØ7AAI          EPSLN = AOVG * (ASYNC/RE)**2
222              C
223              C
224  ØØØ7CCI     269 FORMAT(I1)
225  ØØØ7DCI     169 FORMAT(G18.7)
226              C
227  ØØØ7FØI          RETURN
228  ØØØ7F6I          END
```

```
  1             CD0
  2  0000000I         SUBROUTINE EDERIV(TAU,DEPVAR,DERIVS)
  3             CD0 (TAB STOPS ARE 7,10,12,22,25,28,39)
  4             CD0
  5             CD0      PROGRAMMED BY:              OTIS F. GRAF , ACM,INC.
  6             CD0                                  FEBRUARY 1980
  7             CD0
  8             CD0
  9             CD0      CODE MODIFIED BY:           OTIS F. GRAF , ACM,INC.
 10             CD0                                  25 APRIL 1980
 11             CD0
 12             CD0
 13             CD0      DOCUMENTATION UPDATED BY:   OTIS F. GRAF , ACM,INC.
 14             CD0                                  21 APRIL 1980
 15             CD0
 16             C=====================================================================
 17             CD1
 18             CD1    PURPOSE
 19             CD1
 20             CD1    This routine computes the derivatives for the change in
 21             CD1    eccentricity of an inclined geosynchronous orbit.
 22             CD1
 23             C=====================================================================
 24             CD2
 25             CD2    DEFINITION OF INPUT
 26             CD2
 27             CD2       CALLING ARGUMENTS
 28             CD2
 29             CD2         SYMBOL    D  T  DEFINITION
 30             CD2         ------   --- -  ----------
 31             CD2         TAU       1  D  Independent variable, the eccentric anamoly
 32             CD2                          of the geocentric orbit.
 33             CD2
 34             CD2         DEPVAR    2  D  Dependent variable array.
 35             CD2                          (1): P  ,   (2): Q
 36             CD2                          .
 37             CD2
 38             CD2       COMMON VARIABLES
 39             CD2         S, C, EPSLN, RATE, BP, BQ, SUNPOS
 40             CD2
 41             C=====================================================================
 42             CD3
 43             CD3    DEFINITION OF OUTPUT
 44             CD3
 45             CD3       CALLING ARGUMENTS
 46             CD3
 47             CD3         SYMBOL    D  T  DEFINITION
 48             CD3         ------   --- -  ----------
 49             CD3         DERIVS    2  D  Derivatives of P and Q
 50             CD3
 51             CD3       COMMON VARIABLES
 52             CD3         (NONE)
 53             CD3
 54             C=====================================================================
 55             CD4
 56             CD4    COMMON VARIABLES DEFINITION
 57             CD4
 58             CD4         INTERNAL         COMMON
```

```
 59            CD4          SYMBOL    D  T  SYMBOL      DEFINITION
 60            CD4          -------- --- -  ------      ----------
 61            CD4
 62            C=====================================================================
 63            CD6
 64            CD6   EXTERNAL REFERENCES
 65            CD6
 66            CD6      EXTERNAL ROUTINES
 67            CD6        (NONE)
 68            CD6
 69            C=====================================================================
 70            CD7
 71            CD7   FUNCTIONAL DESCRIPTION
 72            CD7
 73            CD7   The routine uses the non-singular elements  P  and  Q , which are
 74            CD7   derived in Reference 1.  The right hand sides of the differential
 75            CD7   equations for P and Q are computed, using eq. (3.47) in Reference 1.
 76            CD7
 77            C=====================================================================
 78            CD8
 79            CD8   ASSUMPTIONS AND LIMITATIONS
 80            CD8
 81            CD8   1) It is assumed that the eccentricity of the orbit is small.
 82            CD8
 83            C=====================================================================
 84            CD10
 85            CD10  REFERENCES
 86            CD10
 87            CD10  (1) Graf, O.F.: "Orbital Motion of the Solar Power Satellite",
 88            CD10      ACM Technical Report TR-105, May, 1977.
 89            CD10
 90            C*********************************************************************
 91            C     SPECIFICATION STATEMENTS
 92            C     ------------------------
 93            C
 94            C     IMPLICIT
 95            C     --------
 96   000004I        IMPLICIT DOUBLE PRECISION (A-H,O-Z)
 97            C
 98            C     DIMENSION
 99            C     ---------
100   000004I        DIMENSION DEPVAR(2) , DERIVS(2)
101            C
102            C     COMMON
103            C     ------
104   000004I        COMMON /CONST  /CONST(10)
105   000004I        COMMON /DGCON  /DGCON(10)
106            C
107            C     EQUIVALENCE
108            C     -----------
109   000004I        EQUIVALENCE (S      ,DGCON ( 8)),
110                 *            (C      ,DGCON ( 9)),
111                 *            (EPSLN  ,CONST ( 4)),
112                 *            (RATE   ,CONST ( 5)),
113                 *            (BP     ,CONST ( 6)),
114                 *            (BQ     ,CONST ( 7)),
115                 *            (SUNPOS ,CONST (10))
116            C
```

```
117             C*************************************************************
118             C
119   ØØØØØ4I           P = DEPVAR(1)
12Ø   ØØØØ24I           Q = DEPVAR(2)
121             C
122   ØØØØ34I           TERM  = DSQRT(2.DØ - (BP**2 + BQ**2))
123   ØØØØ86I           ES    = 1.DØ - (P**2 + Q**2)
124   ØØØØBCI           COSNU = DCOS(RATE*TAU + SUNPOS)
125   ØØØØF2I           SINNU = DSIN(RATE*TAU + SUNPOS)
126             C
127   ØØØ126I           DERIVS(1) = 1.5*EPSLN*((ES*BP*BQ + Q*BQ*(Q*BP+BQ*P))*COSNU -
128             C
129                    - (ES*C*(1.DØ-BP**2) + ES*S*BP*TERM - C*Q*BP*(Q*BP+BQ*P) +
13Ø             C
131                    + S*Q*(Q*BP+BQ*P)*(1.DØ-(BQ**2+BP**2))/TERM)*SINNU)
132             C
133             C
134   ØØØ264I           DERIVS(2) = 1.5*EPSLN*((ES*(1.DØ-BQ**2)-P*BQ*(Q*BP+BQ*P))*COSNU-
135             C
136                    - (ES*C*BP*BQ - ES*S*BQ*TERM + C*P*BP*(Q*BP + BQ*P) -
137             C
138                    - S*P*(Q*BP + BQ*P)*(1.DØ - (BQ**2 + BP**2))/TERM)*SINNU)
139             C
14Ø             C
141   ØØØ3AØI           RETURN
142   ØØØ3A6I           END
NO  ERRORS:F7D  RØ3-ØØ.Ø   SUBROUTINE  EDERIV  Ø5/Ø1/8Ø  Ø9:39:17  TABLE SPACE:   2 KB
STATEMENT BUFFER:   2Ø LINES/1321 BYTES    STACK SPACE: 189 WORDS
SINGLE PRECISION FLOATING PT SUPPORT REQUIRED FOR EXECUTION
DOUBLE PRECISION FLOATING PT SUPPORT REQUIRED FOR EXECUTION
```

ROUTINES IN PROGRAM LDRIFT

```
  1             CDØ
  2  ØØØØØØI          PROGRAM LDRIFT
  3             CDØ (TAB STOPS ARE 7,1Ø,12,22,25,28,39)
  4             CDØ
  5             CDØ      PROGRAMMED BY:              OTIS F. GRAF , ACM,INC.
  6             CDØ                                  DECEMBER 1979
  7             CDØ
  8             CDØ
  9             CDØ      CODE MODIFIED BY:           OTIS F. GRAF , ACM,INC.
 1Ø             CDØ                                   9 APRIL 198Ø
 11             CDØ
 12             CDØ
 13             CDØ      DOCUMENTATION UPDATED BY:   OTIS F. GRAF , ACM,INC.
 14             CDØ                                  19 FEBRUARY 198Ø
 15             CDØ
 16             C=====================================================================
 17             CD1
 18             CD1    PURPOSE
 19             CD1
 2Ø             CD1    This program computes and plots the long term longitude drift
 21             CD1    of a geosynchronous satellite in a nearly circular orbit.
 22             CD1
 23             C=====================================================================
 24             CD2
 25             CD2    DEFINITION OF INPUT
 26             CD2
 27             CD2       TERMINAL INPUTS
 28             CD2
 29             CD2         SYMBOL     D  T  DEFINITION
 3Ø             CD2         ------    --- -  ----------
 31             CD2         INC        1  D  Orbit inclination (Degrees)
 32             CD2
 33             CD2
 34             C=====================================================================
 35             CD3
 36             CD3    DEFINITION OF OUTPUT
 37             CD3
 38             CD3       TERMINAL OUTPUT
 39             CD3
 4Ø             CD3         SYMBOL     D  T  DEFINITION
 41             CD3         ------    --- -  ----------
 42             CD3         TIME       1  D  Time of propagation (Days)
 43             CD3
 44             CD3         LNG        1  D  Earth-referenced longitude of ascending
 45             CD3                           crossing point on the equator, measured
 46             CD3                           from the Greenwich meridian. Positive is
 47             CD3                           east of Greenwich, negative is west. (Degrees)
 48             CD3                           This is also the longitude of the ascending
 49             CD3                           node, relative to the rotating earth.
 5Ø             CD3
 51             CD3         LNGD       1  D  Rate of change of earth-referenced longitude of
 52             CD3                           of ascending crossing point (Degrees)
 53             CD3
 54             CD3
 55             CD3       DATA FILES
 56             CD3
 57             CD3         SYMBOL     D   T   DEFINITION
 58             CD3         ------    ---  -   ----------
```

```
CD3          XOUT      2   R   (1): X-component of data to be plotted
CD3                              (2): Y-component of data to be plotted
CD3
C=====================================================================
CD4
CD4   COMMON VARIABLES DEFINITION
CD4
CD4        INTERNAL              COMMON
CD4         SYMBOL    D  T      SYMBOL      DEFINITION
CD4        --------  --- -      ------      ----------
CD4        PI          1  D   DPICON(1)   Mathematical constant Pi
CD4        TWOPI       1  D   DPICON(2)   2*Pi
CD4        HALFPI      1  D   DPICON(3)   Pi/2
CD4        DTOR        1  D   DPICON(4)   Conversion factor degrees to radians
CD4        RTOD        1  D   DPICON(5)   Radians to degrees
CD4        MNTODY      1  D   DPICON(5)   Minutes to days
CD4        DYTOMN      1  D   DPICON(6)   Days to minutes
CD4        MUE         1  D   DGCON( 1)   Earth gravitational parameter,
CD4                                        units are (ER cu)/(min sq)
CD4        WE          1  D   DGCON( 2)   Rotation rate of the earth (rad/min)
CD4        J2          1  D   DGCON( 3)   Oblateness geopotential parameter
CD4        J22         1  D   DGCON( 4)   Equatorial ellipticity geopotential
CD4                                        parameter (non-dimensional)
CD4        LAM22       1  D   DGCON( 5)   Equatorial ellipticity geopotential
CD4                                        parameter (radians)
CD4        RE          1  D   DGCON( 6)   Earth equatorial radius(earth radii)
CD4        APERW       1  D   DGCON( 7)   Satellite cross-sectional area
CD4                                        divided by weight (meters sq/kg)
CD4        S           1  D   DGCON( 8)   Sine of the ecliptic angle
CD4        C           1  D   DGCON( 9)   Cosine of the ecliptic angle
CD4        FI          1  D   CONST( 1)   Inclination function for J22 term
CD4        F22         1  D   CONST( 2)   Abbreviation for J22 term
CD4        ASYNC       1  D   CONST( 3)   Semi-major axis for geosynchronous
CD4                                        orbit (earth radii)
CD4        EPSLN       1  D   CONST( 4)   Small parameter used in the solar
CD4                                        radiation pressure equations
CD4        RATE        1  D   CONST( 5)   Angular rate used in solar radition
CD4                                        pressure equations. 1.D0/365.25D0
CD4        BP          1  D   CONST( 6)   Non-singular element for inclination
CD4        BQ          1  D   CONST( 7)   Non-singular element for inclination
CD4        INC         1  D   CONST( 8)   Orbital inclination (rad)
CD4        ASCND       1  D   CONST( 9)   Ascending node (rad)
CD4        SUNPOS      1  D   CONST(10)   Angular position of the sun in the
CD4                                        ecliptic plane, measured from the
CD4                                        vernal equinox (rad)
CD4
C=====================================================================
CD6
CD6   EXTERNAL REFERENCES
CD6
CD6      EXTERNAL ROUTINES
CD6        LINPUT, RKF45
CD6
C=====================================================================
CD7
CD7   FUNCTIONAL DESCRIPTION
CD7
CD7
```

```
117             C=====================================================================
118             CD8
119             CD8   ASSUMPTIONS AND LIMITATIONS
120             CD8
121             CD8      (NONE)
122             CD8
123             C=====================================================================
124             CD9
125             CD9   SPECIAL COMMENTS
126             CD9
127             CD9      (NONE)
128             CD9
129             C=====================================================================
130             CD10
131             CD10  REFERENCES
132             CD10
133             CD10
134             C*********************************************************************
135             C     SPECIFICATION STATEMENTS
136             C     ------------------------
137             C
138             C     IMPLICIT
139             C     --------
140   000006I         IMPLICIT DOUBLE PRECISION (A-H,O-Z)
141             C
142             C     DOUBLE PRECISION
143             C     ----------------
144   000006I         DOUBLE PRECISION LNG0   ,   LNG    ,   LNGD0  ,   LNGD   ,
145                  *                 MUE    ,   J2     ,   J22    ,   MNTODY,
146                  *                 INC
147             C
148             C     REAL
149             C     ----
150   0000Z5I         REAL XOUT
151             C
152             C     DIMENSION
153             C     ---------
154   000006I         DIMENSION DEPVAR(2)  ,  WRKARY(14)  ,  SCALE(2) , XOUT(2)
155             C
156             C     COMMON
157             C     ------
158   000006I         COMMON /CONST  /CONST(10)
159   000006I         COMMON /DGCON  /DGCON(10)
160   000006I         COMMON /DPICON /DPICON(10)
161             C
162             C     EQUIVALENCE
163             C     -----------
164   000006I         EQUIVALENCE (PI     ,DPICON( 1)),
165                  *              (TWOPI  ,DPICON( 2)),
166                  *              (HALFPI ,DPICON( 3)),
167                  *              (DTOR   ,DPICON( 4)),
168                  *              (RTOD   ,DPICON( 5)),
169                  *              (MNTODY ,DPICON( 6)),
170                  *              (DYTOMN ,DPICON( 7))
171   000006I         EQUIVALENCE (MUE    ,DGCON ( 1)),
172                  *              (WE     ,DGCON ( 2)),
173                  *              (J2     ,DGCON ( 3)),
174                  *              (J22    ,DGCON ( 4)),
```

```
175                     *            (LAM22  ,DGCON ( 5)),
176                     *            (RE     ,DGCON ( 6))
177  ØØØFØ6I             EQUIVALENCE (FI     ,CONST ( 1)),
178                     *            (F22    ,CONST ( 2)),
179                     *            (ASYNC  ,CONST ( 3))
180                C
181                C     EXTERNAL
182                C     --------
183  ØØØØØ6I             EXTERNAL LDERIV
184                C
185                C     DATA
186                C     ----
187  ØØØØØ6I             DATA SCALE /2*1.DØ/,
188                     *     IFLAG /1/,
189                     *     NDEQ  /2/,
190                     *     TOL   /1.DØ/,
191                     *     DUM   /Ø.DØ/
192  ØØØØBCI             DATA PLOTFL /'PLOT.DAT'/,
193                     *     LRLTH /8/
194                C
195                C
196                C*********************************************************************
197                C
198  ØØØØC8I             CALL CFILW(PLOTFL,2,LRLTH,1,1,Ø,Ø,ISTAT)
199  ØØØ124I             IF(ISTAT.EQ.4) THEN
200  ØØØ134I                CALL DFILW(PLOTFL,Ø,Ø,ISTAT)
201  ØØØ168I                CALL CFILW(PLOTFL,2,LRLTH,1,1,Ø,Ø,ISTAT)
202  ØØØ1C4I             ENDIF
203  ØØØ1CAI             CALL OPENW(6,PLOTFL,4,Ø,Ø,ISTAT)
204                C
205  ØØØ214I             CALL LINPUT(LNGØ,LNGDØ,INC,DTAUS,TAUF,ISTOP,IPLOT)
206                C
207  ØØØ244I           5ØØ CONTINUE
208  ØØØ244I             DEPVAR(1) = LNGØ
209  ØØØ24EI             DEPVAR(2) = LNGDØ
210  ØØØ258I             TAU = Ø.DØ
211  ØØØ264I             DTAU = DTAUS
212  ØØØ27ØI             NUMSTP = Ø
213  ØØØ278I             ISTART = 1
214                C
215  ØØØ28ØI             IF(IPLOT.EQ.2) THEN
216  ØØØ29ØI                XOUT(1) = Ø.Ø
217  ØØØ29AI                XOUT(2) = SNGL(LNGØ*RTOD)
218  ØØØ2C8I                WRITE(6) XOUT
219  ØØØ32ØI             ENDIF
220                C
221  ØØØ326I             IF(IPLOT.EQ.1) THEN
222  ØØØ336I                XOUT(1) = SNGL(LNGØ*RTOD)
223  ØØØ364I                XOUT(2) = SNGL(LNGDØ*RTOD)
224  ØØØ39ØI                WRITE(6) XOUT
225  ØØØ3E8I             ENDIF
226                C
227  ØØØ3EEI             WINC = INC*RTOD
228  ØØØ4ØØI             WRITE (5,2Ø1) WINC
229  ØØØ454I           2Ø1 FORMAT(' INCLINATION =',F8.2)
230  ØØØ478I             LNG = DEPVAR(1)*RTOD
231  ØØØ488I             LNGD = DEPVAR(2)*RTOD/MNTODY
232  ØØØ49EI             TIME = TAU*MNTODY
```

```
233  ØØØ4BØI          WRITE (5,2ØØ) NUMSTP,TIME,LNG,LNGD
234                C
235  ØØØ51ØI       1ØØØ CONTINUE
236  ØØØ51ØI           NUMSTP = NUMSTP + 1
237  ØØØ51EI           SVLNG = DEPVAR(1)
238  ØØØ528I           SVLNGD = DEPVAR(2)
239  ØØØ532I           SVTAU = TAU
240                C
241  ØØØ53EI           CALL RKF45(TAU,DTAU,DUM,DEPVAR,SCALE,TOL,NDEQ,IFLAG,LDERIV,
242                   * NREJCT,WRKARY,IERR)
243                C
244  ØØØ58ØI           LNG = DEPVAR(1)*RTOD
245  ØØØ59ØI           LNGD = DEPVAR(2)*RTOD/MNTODY
246  ØØØ5A6I           TIME = TAU*MNTODY
247                C
248  ØØØ5B8I           WRITE (5,2ØØ) NUMSTP,TIME,LNG,LNGD
249  ØØØ618I       2ØØ FORMAT(1X,I3,2X,'TIME = ',F6.Ø,2X,'LNG =',F8.2,2X,'LNGD =',F8.4)
250                C
251  ØØØ65CI           IF(IPLOT.EQ.2) GO TO 1ØØ
252  ØØØ672I           XOUT(1) = SNGL(LNG)
253  ØØØ68CI           XOUT(2) = SNGL(LNGD)
254  ØØØ6A8I           WRITE(6) XOUT
255  ØØØ7ØØI           CHKLNG = DABS(DEPVAR(1) - LNGØ)
256  ØØØ72EI           FIVDEG = 5.DØ*DTOR
257  ØØØ74ØI           HAFDEG = .5DØ*DTOR
258  ØØØ752I           IF(ISTART.EQ.1) THEN
259  ØØØ762I              IF(CHKLNG.GT.FIVDEG) THEN
260  ØØØ774I                 ISTART = Ø
261  ØØØ77CI              ENDIF
262  ØØØ782I              GO TO 1ØØØ
263  ØØØ786I           ENDIF
264  ØØØ78CI           IF(CHKLNG.GT.HAFDEG) GO TO 1ØØØ
265  ØØØ7A2I           MNGD = DEPVAR(2)*RTOD/MNTODY
266  ØØØ7BAI           IF(DABS(LNGD).LT.1.D-4) GO TO 15Ø
267  ØØØ7E2I           DTAU = (TAU-SVTAU)*(Ø.DØ-SVLNGD)/(DEPVAR(2)-SVLNGD)
268  ØØØ80EI           TAU = SVTAU
269  ØØØ81AI           DEPVAR(1) = SVLNG
270  ØØØ824I           DEPVAR(2) = SVLNGD
271  ØØØ82EI           GO TO 1ØØØ
272                C
273  ØØØ832I       15Ø CONTINUE
274  ØØØ832I           WRITE (5,151)
275  ØØØ86CI       151 FORMAT(' INPUT LNGØ (DEG) - G18.7')
276  ØØØ894I           READ (5,169) LNGØ
277  ØØØ8E8I           IF(LNGØ.LT.Ø.DØ) GO TO 9999
278  ØØØ9ØØI           LNGØ = LNGØ*DTOR
279  ØØØ912I           GO TO 5ØØ
280                C
281                C
282  ØØØ916I       1ØØ CONTINUE
283  ØØØ916I           XOUT(1) = SNGL(TIME)
284  ØØØ93ØI           XOUT(2) = SNGL(LNG)
285  ØØØ94CI           WRITE(6) XOUT
286  ØØØ9A4I           IF(TAU.LT.TAUF) GO TO 1ØØØ
287  ØØØ9BAI           WRITE (5,1Ø1)
288  ØØØ9F4I       1Ø1 FORMAT(' INPUT INCLINATION (DEG) - G18.7')
289  ØØØA24I           READ (5,169) INC
290  ØØØA78I           IF(INC.LT.Ø.DØ) GO TO 9999
```

```
291  ØØØA9ØI          INC = INC*DTOR
292  ØØØAA2I          FI = (1.DØ + DCOS(INC))**2/4.DØ
293  ØØØAD4I          GO TO 5ØØ
294             C
295  ØØØAD8I      169 FORMAT(G18.7)
296  ØØØAECI     9999 CONTINUE
297  ØØØAECI          CALL EXIT
298             C
299  ØØØAF8I          END
```

NO ERRORS:F7D RØ3-ØØ.Ø MAINPROG LDRIFT Ø5/Ø1/8Ø Ø9:35:58 TABLE SPACE: 4 KB
STATEMENT BUFFER: 2Ø LINES/1321 BYTES STACK SPACE: 136 WORDS
SINGLE PRECISION FLOATING PT SUPPORT REQUIRED FOR EXECUTION
DOUBLE PRECISION FLOATING PT SUPPORT REQUIRED FOR EXECUTION

```
  1             CDØ
  2  ØØØØØØI          SUBROUTINE LINPUT(LNGØ,LNGDØ,INC,DTAU,TAUF,ISTOP,IPLOT)
  3             CDØ (TAB STOPS ARE 7,1Ø,12,22,25,28,39)
  4             CDØ
  5             CDØ      PROGRAMMED BY:              OTIS F. GRAF , ACM,INC.
  6             CDØ                                  JANUARY 198Ø
  7             CDØ
  8             CDØ
  9             CDØ      CODE MODIFIED BY:           OTIS F. GRAF , ACM,INC.
 1Ø             CDØ                                  17 MARCH 198Ø
 11             CDØ
 12             CDØ
 13             CDØ      DOCUMENTATION UPDATED BY:   OTIS F. GRAF , ACM,INC.
 14             CDØ                                  18 FEBRUARY 198Ø
 15             CDØ
 16             C=====================================================================
 17             CD1
 18             CD1    PURPOSE
 19             CD1
 2Ø             CD1    This is the input and data initialization routine for the
 21             CD1    LDRIFT program.
 22             CD1
 23             C=====================================================================
 24             CD2
 25             CD2    DEFINITION OF INPUT
 26             CD2
 27             CD2       CALLING ARGUMENTS
 28             CD2
 29             CD2         SYMBOL     D  T  DEFINITION
 3Ø             CD2         ------    --- -  ----------
 31             CD2
 32             CD2
 33             CD2
 34             CD2       COMMON VARIABLES
 35             CD2
 36             C=====================================================================
 37             CD3
 38             CD3    DEFINITION OF OUTPUT
 39             CD3
 4Ø             CD3       CALLING ARGUMENTS
 41             CD3
 42             CD3         SYMBOL     D  T  DEFINITION
 43             CD3         ------    --- -  ----------
 44             CD3
 45             CD3
 46             CD3       COMMON VARIABLES
 47             CD3
 48             C=====================================================================
 49             CD4
 5Ø             CD4    COMMON VARIABLES
 51             CD4
 52             CD4       DEFINITION
 53             CD4
 54             CD4         INTERNAL          COMMON
 55             CD4          SYMBOL    D  T  SYMBOL      DEFINITION
 56             CD4         --------- --- - ------      ----------
 57             CD4
 58             C=====================================================================
```

```
 59             CD5
 60             CD5   INTERNAL VARIABLES
 61             CD5
 62             CD5         SYMBOL    D  T  DEFINITION
 63             CD5         ------    -  -  ----------
 64             CD5
 65             C=====================================================================
 66             CD6
 67             CD6   EXTERNAL REFERENCES
 68             CD6
 69             CD6      EXTERNAL ROUTINES
 70             CD6
 71             CD6
 72             C=====================================================================
 73             CD7
 74             CD7   FUNCTIONAL DESCRIPTION
 75             CD7
 76             CD7
 77             C=====================================================================
 78             CD8
 79             CD8   ASSUMPTIONS AND LIMITATIONS
 80             CD8
 81             CD8      (NONE)
 82             CD8
 83             C=====================================================================
 84             CD9
 85             CD9   SPECIAL COMMENTS
 86             CD9
 87             CD9      (NONE)
 88             CD9
 89             C=====================================================================
 90             CD10
 91             CD10  REFERENCES
 92             CD10
 93             CD10
 94             C*********************************************************************
 95             C*    SPECIFICATION STATEMENTS
 96             C*    ------------------------
 97             C
 98             C     IMPLICIT
 99             C     --------
100  000004I          IMPLICIT DOUBLE PRECISION (A-H,O-Z)
101            C
102            C     DOUBLE PRECISION
103            C     ----------------
104  000004I          DOUBLE PRECISION  LNG0   ,   LNGD0  ,   INC    ,  MUE   ,
105                 *                  LAM22  ,   J2      ,   J22    ,  MNTODY
106            C
107            C     INTEGER
108            C     -------
109            C
110            C     DIMENSION
111            C     ---------
112            C
113            C     COMMON
114            C     ------
115  000004I          COMMON /CONST  /CONST(10)
116  000004I          COMMON /DGCON  /DGCON(10)
```

```
117  ØØØØØ4I          COMMON /DPICON /DPICON(1Ø)
118              C
119              C     EQUIVALENCE
120              C     -----------
121  ØØØØØ4I          EQUIVALENCE (PI      ,DPICON( 1)),
122                  *            (TWOPI   ,DPICON( 2)),
123                  *            (HALFPI  ,DPICON( 3)),
124                  *            (DTOR    ,DPICON( 4)),
125                  *            (RTOD    ,DPICON( 5)),
126                  *            (MNTODY  ,DPICON( 6)),
127                  *            (DYTOMN  ,DPICON( 7))
128  ØØØØØ4I          EQUIVALENCE (MUE     ,DGCON ( 1)),
129                  *            (WE      ,DGCON ( 2)),
130                  *            (J2      ,DGCON ( 3)),
131                  *            (J22     ,DGCON ( 4)),
132                  *            (LAM22   ,DGCON ( 5)),
133                  *            (RE      ,DGCON ( 6))
134  ØØØØØ4I          EQUIVALENCE (FI      ,CONST ( 1)),
135                  *            (F22     ,CONST ( 2)),
136                  *            (ASYNC   ,CONST ( 3))
137              C
138              C*********************************************************************
139              C
140  ØØØØØ4I          PI = 3.141592653589793DØ
141  ØØØØ1ØI          TWOPI = 2.DØ*PI
142  ØØØØ22I          RTOD = 18Ø.DØ/PI
143  ØØØØ34I          DTOR = PI/18Ø.DØ
144  ØØØØ46I          MNTODY = 1.ØDØ/144Ø.DØ
145  ØØØØ58I          DYTOMN = 144Ø.DØ
146              C
147  ØØØØ64I          J2     = 1.Ø8248D-3
148  ØØØØ7ØI          J22    = 1.7711563D-6
149  ØØØØ7CI          LAM22  = 75.Ø73DØ * DTOR
150  ØØØØ8EI          WE     = 4.375269513D-3
151  ØØØ9AI           MUE    = 5.53Ø263286D-3
152  ØØØØA6I          RE     = 1.DØ
153              C
154  ØØØØB2I          ASYNC = 6.61Ø668747DØ
155  ØØØØBEI          F22   =  6.DØ*MUE/(ASYNC**2)*(RE/ASYNC)**2*J22
156              C
157              C
158  ØØØØFEI          WRITE (5,1ØØ)
159  ØØØ138I      1ØØ FORMAT(' INPUT LNGØ & LNGDØ (DEG, DEG/DAY) - G18.7')
160  ØØØ17ØI          READ (5,169) LNGØ
161  ØØØ1C4I          READ (5,169) LNGDØ
162  ØØØ218I          LNGØ = LNGØ * DTOR
163  ØØØ22AI          LNGDØ = LNGDØ * DTOR/DYTOMN
164              C
165  ØØØ242I          WRITE (5,1Ø1)
166  ØØØ27CI      1Ø1 FORMAT(' INPUT INCLINATION (DEG) - G18.7')
167  ØØØ2ACI          READ (5,169) INC
168  ØØØ3ØØI          INC = INC * DTOR
169              C
170  ØØØ312I          WRITE (5,1Ø2)
171  ØØØ34CI      1Ø2 FORMAT(' INPUT DTAU & TAUF (DAYS) - G18.7')
172  ØØØ37CI          READ (5,169) DTAU
173  ØØØ3DØI          READ (5,169) TAUF
174  ØØØ424I          DTAU=DTAU*DYTOMN
```

```
175  ØØØ436I          TAUF = TAUF*DYTOMN
176              C
177  ØØØ448I          WRITE (5,1Ø3)
178  ØØØ484I        1Ø3 FORMAT(' INPUT STOP FLAG - I1'/' 1 : STOP ON TIME'/
179                    * ' 2 : STOP ON ORBIT')
18Ø  ØØØ4DØI          READ (5,269) ISTOP
181              C
182  ØØØ524I          WRITE (5,1Ø4)
183  ØØØ56ØI        1Ø4 FORMAT(' INPUT PLOT FLAG - I1'/' 1 : LNG VS LNG DOT'/
184                    * ' 2 : LNG VS TIME')
185  ØØØ5ACI          READ (5,269) IPLOT
186              C
187              C
188  ØØØ6ØØI          FI = (1.DØ + DCOS(INC))**2/4.DØ
189              C
19Ø              C
191  ØØØ634I        269 FORMAT(I1)
192  ØØØ644I        169 FORMAT(G18.7)
193              C
194  ØØØ658I          RETURN
19?  ØØØ65EI          END
NO  ERRORS:F7D  RØ3-ØØ.Ø   SUBROUTINE  LINPUT  Ø5/Ø1/8Ø  Ø9:36:31  TABLE SPACE:   3 KB
STATEMENT BUFFER:   2Ø LINES/1321 BYTES    STACK SPACE:  88 WORDS
DOUBLE PRECISION FLOATING PT SUPPORT REQUIRED FOR EXECUTION
```

```
  1             CDØ
  2  ØØØØØØI          SUBROUTINE LDERIV(TAU,DEPVAR,DERIVS)
  3             CDØ (TAB STOPS ARE 7,1Ø,12,22,25,28,39)
  4             CDØ
  5             CDØ      PROGRAMMED BY:              OTIS F. GRAF , ACM,INC.
  6             CDØ                                  DECEMBER 1979
  7             CDØ
  8             CDØ
  9             CDØ      CODE MODIFIED BY:           OTIS F. GRAF , ACM,INC.
 1Ø             CDØ                                  2Ø FEBRUARY 198Ø
 11             CDØ
 12             CDØ
 13             CDØ      DOCUMENTATION UPDATED BY:   OTIS F. GRAF , ACM,INC.
 14             CDØ                                  2Ø FEBRUARY 198Ø
 15             CDØ
 16             C=====================================================================
 17             CD1
 18             CD1    PURPOSE
 19             CD1
 2Ø             CD1    This routine computes the derivatives for the longitude drift
 21             CD1    of an inclined geosynchronous orbit.
 22             CD1
 23             C=====================================================================
 24             CD2
 25             CD2    DEFINITION OF INPUT
 26             CD2
 27             CD2       CALLING ARGUMENTS
 28             CD2
 29             CD2         SYMBOL     D  T  DEFINITION
 3Ø             CD2         ------    --- -  ----------
 31             CD2
 32             CD2       COMMON VARIABLES
 33             CD2         LAM22 , FI , F22 , ASYNC
 34             CD2
 35             C=====================================================================
 36             CD3
 37             CD3    DEFINITION OF OUTPUT
 38             CD3
 39             CD3       CALLING ARGUMENTS
 4Ø             CD3
 41             CD3         SYMBOL     D  T  DEFINITION
 42             CD3         ------    --- -  ----------
 43             CD3
 44             CD3       COMMON VARIABLES
 45             CD3         (NONE)
 46             CD3
 47             C=====================================================================
 48             CD4
 49             CD4    COMMON VARIABLES DEFINITION
 5Ø             CD4
 51             CD4          INTERNAL          COMMON
 52             CD4           SYMBOL    D  T  SYMBOL      DEFINITION
 53             CD4          --------  --- -  ------      ----------
 54             CD4
 55             C=====================================================================
 56             CD5
 57             CD5    INTERNAL VARIABLES
 58             CD5
```

```
 59            CD5        SYMBOL    D  T  DEFINITION
 60            CD5        ------   --- -  ----------
 61            CD5
 62            C=====================================================================
 63            CD6
 64            CD6   EXTERNAL REFERENCES
 65            CD6
 66            CD6      EXTERNAL ROUTINES
 67            CD6
 68            CD6
 69            C=====================================================================
 70            CD7
 71            CD7   FUNCTIONAL DESCRIPTION
 72            CD7
 73            CD7
 74            C=====================================================================
 75            CD8
 76            CD8   ASSUMPTIONS AND LIMITATIONS
 77            CD8
 78            CD8      (NONE)
 79            CD8
 80            C=====================================================================
 81            CD9
 82            CD9   SPECIAL COMMENTS
 83            CD9
 84            CD9      (NONE)
 85            CD9
 86            C=====================================================================
 87            CD1Ø
 88            CD1Ø  REFERENCES
 89            CD1Ø
 90            CD1Ø
 91            C*********************************************************************
 92            C*    SPECIFICATION STATEMENTS
 93            C*    ------------------------
 94            C
 95            C     IMPLICIT
 96            C     --------
 97  ØØØØØ4I         IMPLICIT DOUBLE PRECISION (A-H,O-Z)
 98            C
 99            C     DOUBLE PRECISION
100            C     ----------------
101  ØØØØØ4I         DOUBLE PRECISION LAM22
102            C
103            C     DIMENSION
104            C     ---------
105  ØØØØØ4I         DIMENSION DEPVAR(2) , DERIVS(2)
106            C
107            C     COMMON
108            C     ------
109  ØØØØØ4I         COMMON /CONST  /CONST(1Ø)
110  ØØØØØ4I         COMMON /DGCON  /DGCON(1Ø)
111            C
112            C     EQUIVALENCE
113            C     -----------
114  ØØØØØ4I         EQUIVALENCE (LAM22  ,DGCON ( 5)),
115                 *           (FI     ,CONST ( 1)),
116                 *           (F22    ,CONST ( 2)),
```

```
117                *             (ASYNC  ,CONST ( 3))
118             C
119             C*************************************************************************
120             C
121   ØØØØØ4I           DERIVS(1) = DEPVAR(2)
122             C
123   ØØØØ28I           DERIVS(2) = -3.DØ/ASYNC*(F22*FI*DSIN(2.DØ*(DEPVAR(1)-LAM22)))
124             C
125   ØØØØ82I           RETURN
126   ØØØØ88I           END
NO  ERRORS:F7D  RØ3-ØØ.Ø   SUBROUTINE  LDERIV  Ø5/Ø1/8Ø  Ø9:37:19  TABLE SPACE:   1 KB
STATEMENT BUFFER:   2Ø LINES/1321 BYTES    STACK SPACE: 2Ø1 WORDS
DOUBLE PRECISION FLOATING PT SUPPORT REQUIRED FOR EXECUTION
```

PROGRAM DELTV

```
  1  0000001          PROGRAM DELTV
  2                C
  3                C     THIS  PROGRAM COMPUTES THE STATION KEEPING DELTA V
  4                C     REQUIREMEMT FOR A GEOSYNCHRONOUS SATELLITE OF ANY
  5                C     INCLINATION OTHER THEN 90 DEGREES
  6                C
  7                C*************************************************************
  8                C
  9                C     DEFINITION OF INPUT
 10                C
 11                C     INCLN  - ORBIT INCLINATION IN DEGREES
 12                C     LAMDAI - MAXIMUM ALLOWED DRIFT IN LONGITUDE
 13                C
 14                C*************************************************************
 15                C
 16                C     DEFINITION OF VARIABLES
 17                C
 18                C     J22    - EARTH'S EQUATORIAL ELLIPTICITY COEFFICIENT
 19                C     LAMD22 - LONGITUDE OF MAJOR AXIS, EQUATORIAL ELLIPTICITY
 20                C     LAML22 - (MEAN LONGITUDE OF ASCENDING NODE - LAMD22)
 21                C     LSML22 - SAME AS LAML22
 22                C     LAMDA0 - LAMDAI IN RADIUS
 23                C     REF    - MEAN EQUATORIAL RADIUS OF THE EARTH
 24                C     RAS    - SYNCHRONOUS SATELLITE RADIUS IN KM
 25                C     PLOTFL - NAME OF OUTPUT FILE, INPUT TO PLOT ROUTINE
 26                C     LRLTH  - LOGICAL RECORD LENGTH OF OUTPUT DATA FILE
 27                C     DELTLA - DELTA OF LAML22
 28                C     OMEGAE - ROTATIONAL RATE OF THE EARTH
 29                C     RINCLN - ORBIT INCLINATION
 30                C     A22    - CONSTANT TERM IN DRIFT OF LONGITUDE(SEE REFERENCE 1)
 31                C     B22    - CONSTANT TERM IN CHANGE OF SEMI-MAJOR AXIS
 32                C     TDRIFT - HALF THE INTERVAL OF ORBIT CORRECTION
 33                C     DR     - DELTA OF MAGNITUDE OF RADIUS VECTOR
 34                C     DELTAV - DELTA V REQUIREMENT FOR STATION KEEPING
 35                C
 36                C*************************************************************
 37                C
 38                C     REFERENCE
 39                C
 40                C     1) "DRIFT OF AN INCLINED-ORBIT 24 HOUR SATELLITE IN
 41                C         AN EARTH GRAVITY FIELD THROUGH FOURTH ORDER",BY
 42                C         C. A. WAGNER, 1966
 43                C     2) "PERTURBATION OF A SYNCHRONOUS SATELLITE DUE TO
 44                C         TRIAXIALITY OF THE EARTH",BY R. H. FRICK AND
 45                C         T. B. GARBER, 1962
 46                C     3) "INTRODUCTION TO SPACE DYNAMICS", BY W. T. THOMSON,
 47                C         1961
 48                C
 49                C*************************************************************
 50  000006I             DOUBLE PRECISION PLOTFL
 51                C
 52  000006I             DIMENSION XOUT(2)
 53                C
 54  000006I             REAL INCLN , J22 , LAMD22 , LAMDAI , LAML22 , LSML22
 55  000006I             REAL LAMDA0
 56                C
 57  000006I             EQUIVALENCE (LSML22 , XOUT(1)),
 58                     *            (DELTAV , XOUT(2))
```

```
 59  000006I          DATA REF /6378.14/,
 60                  *     RAS /42159.5/,
 61                  *     PI /3.1415926535/,
 62                  *     J22 /-1.771563E-6/,
 63                  *     LAMD22 /-14.923723/,
 64                  *     LAML22 /-180./,
 65                  *     PLOTFL /'PLOT.DAT'/,
 66                  *     LRLTH /8/,
 67                  *     DELTLA /15./
 68              C
 69  00003CI          TWOTRD = 2./3.
 70  00004EI          DTR = PI/180.
 71  00005EI          TWODTR = 2.0 * DTR
 72  000070I          OMEGAE = 2.*PI
 73              C
 74  000080I          CALL CFILW(PLOTFL,2,LRLTH,1,1,0,0,ISTAT)
 75  0000DCI          IF(ISTAT .EQ. 4) THEN
 76  0000ECI            CALL DFILW(PLOTFL,0,0,ISTAT)
 77  000120I            CALL CFILW(PLOTFL,2,LRLTH,1,1,0,0,ISTAT)
 78  000170I          ENDIF
 79  000182I          CALL OPENW(6,PLOTFL,4,0,0,ISTAT)
 80              C
 81  0001CCI          REWIND 6
 82              C
 83              C     INPUT ORBIT INCLINATION
 84              C
 85  0001F0I        5 CONTINUE
 86  0001F2I          LSML22 = LAML22
 87              C
 88  0001F8I          WRITE(5,50)
 89  000234I          READ (5,100) INCLN
 90  000288I          IF(INCLN .EQ. 90.) GO TO 20
 91  0002A0I          RINCLN = INCLN * DTR
 92  0002B2I          COSI = COS(RINCLN)
 93  0002CEI          FAC = (REF/RAS)**2*J22*(1.+COSI)**2*0.25*PI
 94  000316I          A22 = -72.*PI*FAC
 95  00032CI          B22 = 24.*RAS*FAC
 96              C
 97              C     INPUT INITIAL ALLOWED DRIFT IN DEGREES
 98              C
 99  000342I          WRITE(5,60)
100  00037CI          READ (5,100) LAMDAI
101  0003D0I          LAMDA0 = LAMDAI*DTR
102  0003E2I          WRITE(5,200) INCLN,LAMDAI
103             C
104  000438I          DO 10 I = 1,25
105  000440I          S2LM22 = SIN(TWODTR*LSML22)
106  00046EI          IF(ABS(S2LM22) .LE. 1.0E-4) THEN
107  000490I            DELTAV = 0.
108  00049AI            GO TO 6
109  0004A0I          ENDIF
110  0004A6I          C2LM22 = COS(TWODTR*LSML22)
111  0004D2I          TDRIFT = SQRT(LAMDA0/ABS(A22*S2LM22))
112             C
113  000526I          WRITE(5,225) TDRIFT
114  000578I          DR1 = B22*TDRIFT*S2LM22
115  000590I          DR2 = -DR1*TWODTR*A22*C2LM22*TDRIFT*TDRIFT
116  0005C2I          WRITE(5,250) DR1,DR2
```

```
117  ØØØ618I          DR = DR1 - DR2
118  ØØØ62AI          DELTAV = Ø.5*DR*OMEGAE*365/(86.4*TDRIFT)
119  ØØØ656I        6 CONTINUE
12Ø  ØØØ656I          WRITE(5,275) LSML22,DELTAV
121               C
122  ØØØ6ACI          WRITE(6) XOUT
123  ØØØ7Ø4I          LSML22 = LSML22 + DELTLA
124  ØØØ71ØI       1Ø CONTINUE
125  ØØØ726I          GO TO 5
126  ØØØ72AI       2Ø CONTINUE
127               C
128  ØØØ72AI       5Ø FORMAT(' INPUT ORBIT INCLINATION - G15.7 ')
129  ØØØ75CI       6Ø FORMAT(' INPUT INITIAL ALLOWED DRIFT IN DEGREES - G15.7 ')
13Ø  ØØØ79CI      1ØØ FORMAT(G15.7)
131  ØØØ7BØI      2ØØ FORMAT(/' INCLINATION = ',F8.2,' DEG',' INITIAL ALLOWED DRIFT = ',
132                *       F1Ø.4,' DEG')
133  ØØØ8Ø4I      225 FORMAT(/' TIME BETWEEN CORRECTION = ',E15.7,' DAYS')
134  ØØØ83CI      25Ø FORMAT(/' DR1 = ',E15.7,5X,' DR2 = ',E15.7)
135  ØØØ86CI      275 FORMAT(/' (LAMDS - LAMD22) = ',F9.2,' DEGS',' DELTA V = ',
136                *       E15.7,' M/SEC/YEAR')
137  ØØØ8CØI          CALL EXIT
138  ØØØ8CCI          END
NO  ERRORS:F7D  RØ3-ØØ.Ø   MAINPROG    DELTV   Ø5/Ø1/8Ø  Ø9:34:13  TABLE SPACE:    4 KB
STATEMENT BUFFER:   2Ø LINES/1321 BYTES    STACK SPACE: 134 WORDS
SINGLE PRECISION FLOATING PT SUPPORT REQUIRED FOR EXECUTION
```

PROGRAM DELTVN

```
  1  0000001          PROGRAM DELTVN
  2                C*****************************************************************
  3                C
  4                C     THIS PROGRAM COMPUTES THE OUT PLANE DELTA V
  5                C     REQUIREMENT FOR A SATELLITE IN AN INCLINED
  6                C     NEAR CIRCULAR GEOSYNCHRONOUS ORBIT
  7                C
  8                C*****************************************************************
  9                C
 10                C     DEFINITION OF INPUT
 11                C
 12                C     FLAG   - FLAG IN DETERMINING OUTPUT VARIABLE FOR PLOT
 13                C              = 1 : DELTA V AND INCLINATION
 14                C              = 2 : DELTA V AND ASCENDING NODE
 15                C     INCL   - INITIAL INCLINATION OF THE ORBIT
 16                C     ANODE  - ASCENDING NODE OF THE ORBIT
 17                C
 18                C*****************************************************************
 19                C
 20                C     DEFINITION OF OUTPUT
 21                C
 22                C     XOUT(1) - EITHER INCL OR ANODE BASE ON THE VALUE OF FLAG
 23                C     XOUT(2) - DELTA V REQUIREMEMT FOR STATION-KEEPING (DVDTM)
 24                C
 25                C*****************************************************************
 26                C     DEFINITION OF VARIABLES
 27                C
 28                C     ALPHA  - COEFFICIENT IN COMPUTATION OF dh/dt (SEE REF. 2
 29                C              FOR EXPRESSIONS AND VALUES OF ALPHA, BETA, GAMMA
 30                C              , AND EPS)
 31                C     BETA   - COEFFICIENT IN COMPUTATION OF di/dt AND dh/dt
 32                C     GAMMA  - COEFFICIENT IN COMPUTATION OF di/dt AND dh/dt
 33                C     EPS    - COEFFICIENT IN COMPUTATION OF di/dt AND dh/dt
 34                C     LRLTH  - LOGICAL RECORD LENGTH OF OUTPUT PLOT DATA FILE
 35                C     MTF    - METERS TO FEET CONVERSION FACTOR
 36                C     RS     - RADIUS OF THE CIRCULAR GEOSYNCHRONOUS ORBIT
 37                C              IN KM
 38                C     PLOTFL - VARIABLE NAME OF THE OUTPUT PLOT FILE NAME
 39                C     DTR    - DEGREES TO RADIANS CONVERSION FACTOR
 40                C     RINCL  - INCLINATION IN RADIANS
 41                C     RNODE  - ASCENDING NODE IN RADIANS
 42                C     COSI   - COS(RINCL)
 43                C     SINI   - SIN(RINCL)
 44                C     COSH   - COS(RNODE)
 45                C     SINH   - SIN(RNODE)
 46                C     COS2I  - COS(2*RINCL)
 47                C     SIN2I  - SIN(2*RINCL)
 48                C     COS2H  - COS(2*RNODE)
 49                C     SIN2H  - SIN(2*RNODE)
 50                C     DIDT   - di/dt (SEE REF. 2 FOR EXPRESSIONS OF di/dt
 51                C                     AND dh/dt)
 52                C     DHDT   - dh/dt
 53                C     DVDT   - DELTA V REQUIREMENT IN KM/DAY/DAY
 54                C     DVDTM  - DELTA V REQUIREMEMT IN M/SEC/YEAR
 55                C     DVDTF  - DELTA V REQUIREMEMT IN FT/SEC/YEAR
 56                C
 57                C*****************************************************************
 58                C
```

```
 59              C     SPECIAL COMMENTS
 6Ø              C
 61              C       THE OUTPUT IS IN FORM OF BINARY DATA TO THE PLOT FILE
 62              C     (PLOT.DAT). TO PLOT THE OUTPUT DATA JUST TYPE XQTPLOT IN
 63              C     RESPONSE TO THE SYSTEM PROMPT *. THE PROGRAM WILL PROMPT
 64              C     THE USER FOR REQUIRED INPUT. THE PLOT WILL BE EITHER
 65              C     DELTA V VS. INCLINATION WITH ASCENDING NODE AS THE THIRD
 66              C     PARAMETER OR DELTA V VS. ASCENDING NODE WITH INCLINATION
 67              C     AS THE THIRD PARAMETER.
 68              C
 69              C*************************************************************
 7Ø              C
 71              C     REFERENCES
 72              C
 73              C     1) KAPLAN M. H.,"MODERN SPACECRAFT DYNAMICS & CONTROL",
 74              C        JOHN WILEY & SONS, 1976
 75              C     2) GRAF O. F.," LUNAR AND SOLAR PERTURBATIONS ON THE
 76              C        ORBIT OF A GEOSYNCHRONOUS SATELLITE", AAS 75-Ø33,1975
 77              C
 78              C*************************************************************
 79  ØØØØØ6I           DOUBLE PRECISION PLOTFL
 8Ø              C
 81  ØØØØØ6I           INTEGER FLAG
 82              C
 83  ØØØØØ6I           REAL INCL , MTF
 84              C
 85  ØØØØØ6I           DIMENSION XOUT(2)
 86              C
 87  ØØØØØ6I           EQUIVALENCE (XOUT(2) , DVDTM)
 88              C
 89  ØØØØØ6I           DATA ALPHA  / .6821/,
 9Ø                  *     BETA   / .1729/,
 91                  *     GAMMA  / .Ø189/,
 92                  *     EPS    / .37ØØE-4/,
 93                  *     LRLTH  / 8/,
 94                  *     MTF    / 3.28Ø84/,
 95                  *     RS     / 42159.5/,
 96                  *     PI     / 3.14159265/,
 97                  *     PLOTFL / 'PLOT.DAT'/
 98              C
 99  ØØØØ3CI           DTR = PI / 18Ø.
1ØØ  ØØØØ4CI           TWOPI = 2.Ø * PI
1Ø1  ØØØØ5CI           HALFPI = PI * Ø.5
1Ø2             C
1Ø3  ØØØØ6CI           CALL CFILW(PLOTFL,2,LRLTH,1,1,Ø,Ø,ISTAT)
1Ø4  ØØØØC8I           IF(ISTAT .EQ. 4) THEN
1Ø5  ØØØØD8I             CALL DFILW(PLOTFL,Ø,Ø,ISTAT)
1Ø6  ØØØ1ØCI             CALL CFILW(PLOTFL,2,LRLTH,1,1,Ø,Ø,ISTAT)
1Ø7  ØØØ168I           ENDIF
1Ø8  ØØØ16EI           CALL OPENW(6,PLOTFL,4,Ø,Ø,ISTAT)
1Ø9             C
11Ø  ØØØ1B8I           REWIND 6
111             C
112  ØØØ1DCI           WRITE(5,11Ø)
113  ØØØ218I           READ(5,115) FLAG
114             C
115  ØØØ26CI           IF(FLAG .EQ. 1) THEN
116  ØØØ27CI        2Ø   CONTINUE
```

```
117  00027CI            WRITE(5,50)
118  0002B8I            READ(5,100) ANODE
119  0002F0I            IF(ANODE .LT. 0.) GO TO 300
120  000324I            WRITE(5,55) ANODE
121  000378I            INCL = 0.
122  000384I         30   CONTINUE
123  000384I              WRITE(5,65) INCL
124  0003D8I              RINCL = INCL * DTR
125  0003EAI            ELSE
126  0003F0I         40   CONTINUE
127  0003F0I              WRITE(5,70)
128  00042CI              READ(5,100) INCL
129  000480I              IF(INCL .GT. 90.) GO TO 300
130  000498I              WRITE(5,65) INCL
131  0004ECI              RINCL = INCL * DTR
132  0004FEI              ANODE = 0.
133  00050AI            ENDIF
134               C
135  00050AI         45 CONTINUE
136  00050AI            RNODE = ANODE * DTR
137  00051CI            IF(INCL .EQ. 0.) RNODE = HALFPI
138               C
139               C     COMPUTE RATE OF INCLINATION AND NODE
140               C
141  000534I            COSI = COS(RINCL)
142  000556I            SINI = SIN(RINCL)
143  000572I            COSH = COS(RNODE)
144  00058EI            SINH = SIN(RNODE)
145  0005AAI            SIN2I = 2.0 * SINI * COSI
146  0005C2I            COS2I = 2.0 * COSI**2 - 1.
147  0005E2I            SIN2H = 2.0 * SINH * COSH
148  0005FAI            COS2H = 2.0 * COSH**2 - 1.
149               C
150  00061AI            DIDT = TWOPI * EPS *(BETA * COSI * SINH +
151                   *       2.0 * GAMMA * SINI * SIN2H)
152  000654I            IF(INCL .NE. 0.) THEN
153  000666I              DHDT = TWOPI * EPS *(BETA * COS2I * COSH -
154                   *         (ALPHA - GAMMA * COS2H) * SIN2I) / SINI
155  0006A6I            ELSE
156  0006ACI              DHDT = 0.
157  0006B8I            ENDIF
158  0006B8I            WRITE(5,150) DIDT,DHDT
159               C
160               C     COMPUTE DELTA V REQUIREMENT
161               C
162  000710I            DVDT = RS * TWOPI * SQRT(DIDT**2 + SINI**2 * DHDT**2)
163  000780I            DVDTM = DVDT * 365. / 86.4
164  000796I            DVDTF = DVDTM * MTF
165               C
166  0007A4I            WRITE(5,200) DVDTM,DVDTF
167  0007FCI            IF(FLAG .EQ. 1) THEN
168  000800I              XOUT(1) = INCL
169  000816I            ELSE
170  00081CI              XOUT(1) = ANODE
171  000826I            ENDIF
172  000826I            WRITE(6) XOUT
173  00087CI            IF(FLAG .EQ. 1) THEN
174  000888I              INCL = INCL + 5.
```

```
175  ØØØ89EI            IF(INCL .GT. 9Ø.) GO TO 2Ø
176  ØØØ8B4I            GO TO 3Ø
177  ØØØ8B8I          ELSE
178  ØØØ8BEI            ANODE = ANODE + 3Ø.
179  ØØØ8DØI            IF(ANODE .GT. 36Ø.) GO TO 4Ø
18Ø  ØØØ8E6I            GO TO 45
181  ØØØ8EAI          ENDIF
182  ØØØ8EAI       3ØØ CONTINUE
183  ØØØ8EAI           CALL EXIT
184  ØØØ8F6I        5Ø FORMAT(' INPUT ASCENDING NODE IN DEGREES - G15.7')
185  ØØØ92CI        55 FORMAT(' ASCENDING NODE = ',F7.2,' DEGS')
186  ØØØ95CI        65 FORMAT(' INCLINATION = ',F7.2,' DEGS')
187  ØØØ988I        7Ø FORMAT(' INPUT INCLINATION IN DEGREES - G15.7')
188  ØØØ9BCI       1ØØ FORMAT(G15.7)
189  ØØØ9DØI       15Ø FORMAT(' DIDT = ',E15.7,' DHDT = ',E15.7)
19Ø  ØØØA0ØI       2ØØ FORMAT(' DELTA V = ',F9.2,' M/SES/YEAR',2X,F9.2,' FT/SEC/YEAR')
191  ØØØA44I       11Ø FORMAT(' INPUT PLOT SELECTION FLAG :'/,
192                    *       ' 1 - INCLINATION AS X AXIS'/,
193                    *       ' 2 - ASCENDING NODE AS X AXIS')
194  ØØØABØI       115 FORMAT(I1)
195  ØØØACØI           END
```

NO ERRORS:F7D RØ3-ØØ.Ø MAINPROG DELTVN Ø5/Ø1/8Ø Ø9:34:55 TABLE SPACE: 4 KB
STATEMENT BUFFER: 2Ø LINES/1321 BYTES STACK SPACE: 131 WORDS
SINGLE PRECISION FLOATING PT SUPPORT REQUIRED FOR EXECUTION

ROUTINE PLOTIT

```
  1  ØØØØØØI          SUBROUTINE PLOTIT(XMIN,XMAX,YMIN,YMAX)
  2            C
  3            C     THIS ROUTINE TAKES INPUT FROM A BINARY DATA FILE, AND PLOT
  4            C     THE INPUT ON THE TEKTRONIX TERMINAL. THE INPUT BINARY FILE
  5            C     HAS A RECORD LENGTH OF 2 WORDS(8 BYES). FIRST WORD CONTAINS
  6            C     THE X-COORDINATE VARIABLE(INDEPENDENT VARIABLE), 2ND WORD
  7            C     CONTAINS THE Y-COORDINATE VARIABLE. THE BINARY DATA FILE
  8            C     MUST BE ASSIGNED AS LOGICAL UNIT 6.
  9            C
 1Ø            C*********************************************************************
 11            C
 12            C     DEFINITION OF INPUT
 13            C
 14            C     XMIN - MINIMUM VALUE OF X-COORDINATE OF THE VIRTUAL WINDOW
 15            C     XMAX - MAXIMUM VALUE OF X-COORDINATE OF THE VIRTUAL WINDOW
 16            C     YMIN - MINIMUN VALUE OF Y-COORDIANTE OF THE VIRTUAL WINDOW
 17            C     YMAX - MAXIMUM VALUE OF Y-COORDINATE OF THE VIRTUAL WINDOW
 18            C
 19            C*********************************************************************
 2Ø            C
 21            C     DEFINITION OF VARIABLES
 22            C
 23            C     INCRTX - INCREMENT OF SCREEN X-COORDINATE OF THE TICK MARK
 24            C     INCRTY - INCREMENT OF SCREEN Y-COORDINATE OF THE TICK MARK
 25            C     SXMIN  - MINIMUM VALUE OF SCREEN X-COORDINATE OF PLOTTING
 26            C              BOUNDARY
 27            C     SXMAX  - MAXIMUM VALUE OF SCREEN X-COORDINATE OF PLOTTING
 28            C              BOUNDARY
 29            C     SYMIN  - MINIMUM VALUE OF SCREEN Y-COORDINATE OF PLOTTING
 3Ø            C              BOUNDARY
 31            C     SYMAX  - MAXIMUM VALUE OF SCREEN Y-COORDINATE OF PLOTTING
 32            C              BOUNDARY
 33            C     TICK   - LENGTH OF  THE TICK MARK
 34            C     X      - INPUT X VALUE
 35            C     XSAVE  - SAVED X VALUE
 36            C     Y      - INPUT Y VALUE
 37            C     YSAVE  - SAVED Y VALUE
 38            C
 39            C*********************************************************************
 4Ø            C
 41  ØØØØØ4I          INTEGER SXMIN,SXMAX,SYMIN,SYMAX,SMOVE
 42  ØØØØØ4I          INTEGER FIRST
 43            C
 44  ØØØØØ4I          DIMENSION XIN(2)
 45            C
 46  ØØØØØ4I          EQUIVALENCE (X  , XIN(1)),
 47                 *            (Y  , XIN(2))
 48            C
 49  ØØØØØ4I          DATA FIRST  /1/,
 5Ø                 *     INCRTX /8Ø/,
 51                 *     INCRTY /6Ø/,
 52                 *     SXMIN  /1ØØ/,
 53                 *     SXMAX  /9ØØ/,
 54                 *     SYMIN  /1ØØ/,
 55                 *     SYMAX  /7ØØ/,
 56                 *     TICK   /.125/
 57            C*********************************************************************
 58            C
```

```
 59  0000341          CALL INITT(9600)
 60                C
 61                C     SET UP THE VIRTUAL WINDOW
 62                C
 63  0000541          CALL DWINDO(XMIN,XMAX,YMIN,YMAX)
 64                C
 65                C     SET UP THE SCREEN WINDOW
 66                C
 67  0000781          CALL TWINDO(SXMIN,SXMAX,SYMIN,SYMAX)
 68                C
 69                C     INITIALIZE THE PLOT
 70                C
 71  00009CI          CALL MOVABS(SXMIN,SYMIN)
 72                C
 73                C     PLOT THE SCREEN WINDOW
 74                C
 75  0000B8I          CALL DRWABS(SXMAX,SYMIN)
 76  0000D4I          CALL DRWABS(SXMAX,SYMAX)
 77  0000FØI          CALL DRWABS(SXMIN,SYMAX)
 78  0001ØCI          CALL DRWABS(SXMIN,SYMIN)
 79                C
 80                C     DRAW THE TICK MARK
 81                C
 82  0001281          SMOVE = SXMIN + INCRTX
 83                C
 84  0001361          DO 1Ø I = 1,9
 85  00013EI          CALL MOVABS(SMOVE,SYMIN)
 86  0001581          CALL DRWREL(Ø,KIN(TICK))
 87  0001981          SMOVE = SMOVE + INCRTX
 88  0001A8I       1Ø CONTINUE
 89                C
 90  0001BEI          SMOVE = SYMIN + INCRTY
 91                C
 92  0001CCI          DO 2Ø I = 1,9
 93  0001D4I          CALL MOVABS(SXMIN,SMOVE)
 94  0001FØI          CALL DRWREL(KIN(TICK),Ø)
 95  0002301          SMOVE = SMOVE + INCRTY
 96  0002401       2Ø CONTINUE
 97                C
 98                C     INPUT DATA FROM LOGICAL UNIT 6
 99                C
100  0002561          REWIND 6
101  0002781       5Ø CONTINUE
102                C
103  0002781          READ(6,END=3ØØ) XIN
104  0002D0I          IF(FIRST .EQ. 1) THEN
105  0002DEI            CALL MOVEA(X,Y)
106  0002F8I            FIRST = Ø
107  0002FEI            XSAVE = X
108  0003081            YSAVE = Y
109  0003121            GO TO 5Ø
110  0003161          ELSE IF(X .LE. XMIN) THEN
111  00032CI            CALL MOVEA(X,Y)
112  0003481            GO TO 5Ø
113  00034CI          ELSE IF(X .LE. XSAVE) THEN
114  0003621            CALL DRAWA(XSAVE,YSAVE)
115  00037CI            CALL MOVEA(X,Y)
116  0003981            XSAVE = X
```

```
117  0003A2I            YSAVE = Y
118  0003ACI            GO TO 50
119  0003B0I          ELSE
120  0003B6I            CALL DRAWA(X,Y)
121  0003D0I            GO TO 50
122  0003D4I          ENDIF
123              C
124  0003D4I      300 CONTINUE
125  0003D4I          CALL FINITT(0,0)
126  0004000I         RETURN
127  0004006I         END
```

NO ERRORS:F7D R03-00.0 SUBROUTINE PLOTIT 05/01/80 09:40:02 TABLE SPACE: 2 KB
STATEMENT BUFFER: 20 LINES/1321 BYTES STACK SPACE: 70 WORDS
SINGLE PRECISION FLOATING PT SUPPORT REQUIRED FOR EXECUTION